INSTRUCTION MANUAL

type 1395-P4
POWER AMPLIFIER

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GENERAL RADIO COMPANY

West Concord, Massachusetts

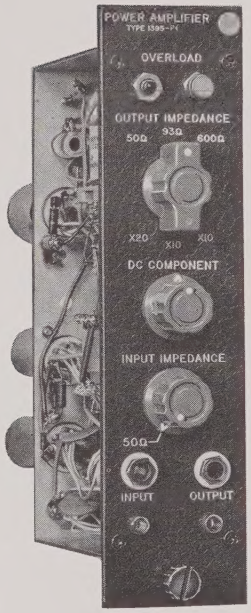

Figure 1-1. Type 1395-P4 Power Amplifier.

SPECIFICATIONS

Output Impedances: 50, 93, and 600 Ω, all ±10%.

Gains: 20, 20, and 26 dB, respectively, at the above impedances and with matched loads, all ±2 dB.

Pulse Output Voltage: ±20 V pulses into 50-Ω load with 10% duty cycle. Larger duty cycles may be used at lower output levels.

Rise and Fall Times: Less than 60 ns on all transitions with a 50-Ω load and selector switch set for 50-Ω impedance.

Sine-Wave Amplifier: Power output into 50- and 93-Ω loads is at least 2.5 W (3% distortion typical); into 600-Ω load, at least 1.5 W (distortion, 1.5% typical).

Frequency Response: Down less than 3 dB at 20 c/s and 5 Mc/s with 50- and 93-Ω loads; 20 c/s and 1.5 Mc/s with 600-Ω load.

Dc Level: Dc baseline of pulses and centerline of sine waves can be moved at least ±1.5 V dc with 50-Ω loads, and more with higher impedance loads.

Input Impedance: Adjustable from 50 to 1050 Ω, shunted by approx 45 pF.

Power Consumption: +150 V at 150 mA, max; −150 V at 150 mA, max; 6.3 V, 60 c/s, 2.2 A; 6.3 V, 60 c/s, 1.9 A. Power supplied by frame.

Accessories Supplied: Four patch cords — one each TYPES 274-LMB, 274-LMR, 274-LSB, and 274-LSR; two insulated plugs, one each TYPES 274-DB1 and 274-DB2.

Net Weight: 2 lb (1 kg).

Shipping Weight: 5 lb (2.3 kg).

SECTION 1

INTRODUCTION

1.1 THE TYPE 1395-A MODULAR PULSE GENERATOR SYSTEM.

The General Radio Type 1395-A Modular Pulse Generator is a customized pulse generator made up of a main frame, which includes power supplies and adder circuits, and various plug-in modules. As requirements change, the plug-in modules can be rearranged in a few minutes to create exactly the pulse generator for the new circumstances. The Type 1395-P4 Power Amplifier described in this instruction book is one of the plug-in modules.

A number of modules are available: Some determine the shape of a pulse; others determine pulse amplitude and duration; still others are amplifiers, pattern generators, or clocks. Wise interconnection of these modules is the key to success. A number of examples are given in the instructions for the Type 1395-A Modular Pulse Generator and in paragraph 2.2 of the instructions for this Power Amplifier, but practice and ingenuity will take the user far beyond the limits of any instruction book.

1.2 DESCRIPTION OF THE POWER AMPLIFIER, TYPE 1395-P4.

The Type 1395-P4 Power Amplifier is the plug-in module used in the Type 1395-A Modular Pulse Generator system to increase the signal level above that supplied by the other modules. The Power Amplifier is a linear amplifier, i.e., the output voltage is directly proportional to the input voltage, so that complicated waveforms can be reproduced exactly. The Power Amplifier is particularly valuable for use with multiple-level pulses and ramp waveforms.

The output of the Power Amplifier matches three commonly used impedance levels: 50, 93, and 600 ohms. The gains at these levels are 10, 10, and 20, respectively, on a voltage basis or 20, 20, and 26 dB. The input impedance is variable between 50 and 1050 ohms. A DC COMPONENT control on the front panel adjusts the baseline of the output voltage. Note that the PULSE DC COMPONENT control on the Type 1395-A main frame does not apply to the Power Amplifier output.

The Power Amplifier is divided into two types of circuits:

a. amplifier circuits comprised of low-level, driver, and output stages.

b. Power-supply circuits comprised of decoupling systems and protective systems.

1.3 CONTROLS AND CONNECTORS.

All controls and connection points required for operation of this instrument are on the front panel, shown in Figure 1-2. Table 1-1 identifies these controls and connectors.

1.4 STORAGE OF SPARE MODULES.

The modules of the 1395 family are shipped sandwiched between sheets of plastic foam. These sheets of foam fit cross-wise in a standard filing cabinet, as do the manila folders commonly used for 8-1/2 by 11 papers. Slip unused modules between foam sheets and store them in a file drawer. They will remain clean and protected, and positioned so that the module type is instantly recognized. If the foam sheets loosen from frequent handling, an elastic band will hold them in place.

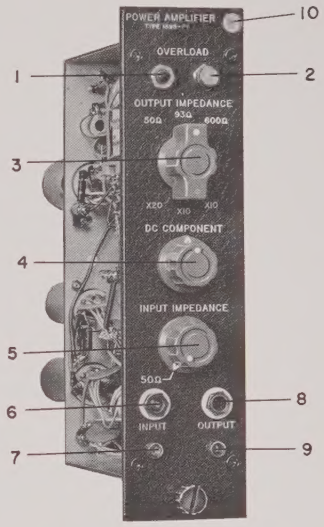

Figure 1-2. Type 1395-P4 Power Amplifier. (For legend, refer to paragraph 1.3.)

TABLE 1-1
CONTROLS AND CONNECTORS

Figure 1-2 Reference	*Name*	*Type*	*Function*
1	OVERLOAD	Push button	Restores power after overload cut-out circuit operates.
2	OVERLOAD	Pilot light	Lights when power is interrupted by overload cut-out circuit.
3	OUTPUT IMPEDANCE	3-position rotary switch	Selects output impedance seen looking back into output terminals.
4	DC COMPONENT	Continuous rotary control	Adjusts dc baseline level of the output signal.
5	INPUT IMPEDANCE	Continuous rotary control	Allows choice of impedance seen looking into input terminals.
6, 7	INPUT	Jacks	Connectors for input voltage (6 high, 7 ground).
8, 9	OUTPUT	Jacks	Connectors for output voltage (8 high, 9 ground).
10	none	Aluminum disk	Write-on tab for identifcation of module in large set-ups.

SECTION 2

OPERATING PROCEDURE

TURN OFF THE POWER BEFORE YOU INSERT OR REMOVE ANY MODULE!

2.1 POWER CONNECTIONS.

To operate the Type 1395-P4 Power Amplifier, four voltages must be supplied: +150 volts dc at 150 mA maximum; -150 volts dc at 150 mA maximum; 6.3 volts ac at 2.2 amperes, offset from ground by +50 volts dc; and 6.3 volts ac at 1.9 amperes, offset from ground by -75 volts dc. The Pulse Amplifier normally obtains these voltages through a 14-pin connector in the Type 1395-A main frame.

The Power Amplifier requires more current than any other module in the 1395 family. To prevent overloading the power supplies, the Power Amplifier is keyed to fit in only the extreme-right-hand position (as viewed from the front) in the Type 1395-A main frame. Thus, only one Power Amplifier can be used at a time. DO NOT ATTEMPT TO USE MORE THAN ONE POWER AMPLIFIER AT ONCE, even though it is possible with the servicing cable connected to another plug.

To connect the Power Amplifier to the Modular Pulse Generator power supplies, simply slide the Power Amplifier into the extreme-right-hand position in the Modular Pulse Generator. When the Power Amplifier is almost fully inserted, check by feel to be sure that the power connectors have started to mate. Then push it in firmly and fasten the thumbscrew on the bottom edge of the panel.

If the Power Amplifier is to be used with a power source other than the Type 1395-A, connection should be made with an Amphenol Number 57-20140 connector or the equivalent.

2.2 INTERCONNECTIONS WITH OTHER 1395 SERIES MODULES.

2.2.1 GENERAL.

Inasmuch as the Type 1395-A Modular Pulse Generator permits the user as much versatility as possible in assembly of pulse-generating equipment, this book cannot possibly cover all interconnections, or even a generous assortment of them. However, some typical uses are described in the following paragraphs.

2.2.2 USE AS AN IMPEDANCE-TRANSFORMING AMPLIFIER.

The Type 1395-P2 Pulse/Delay Unit and the Type 1395-P3 Pulse Shaper are both 20-mA current sources shunted by 1000-ohm potentiometers. Thus, each will deliver 20 volts open-circuit, 10 volts into 1000 ohms external load, 1 volt into 50 ohms, etc. Frequently, an amplitude greater than 1 volt is required into a 50-ohm load. In this situation, the Power Amplifier can be used as an impedance-transforming coupler. The INPUT IMPEDANCE control on the Power Amplifier is set to between 50 and 100 ohms, so that the output current from a Pulse/Delay Unit or a Pulse Shaper will create an input voltage between 1 and 2 volts at the INPUT terminals of the Power Amplifier. The INPUT IMPEDANCE control is not calibrated, but it is linear. The knob is at its 100-ohm setting when about 15° clockwise from the marked 50-ohm point. The OUTPUT IMPEDANCE control is set to 50 ohms.

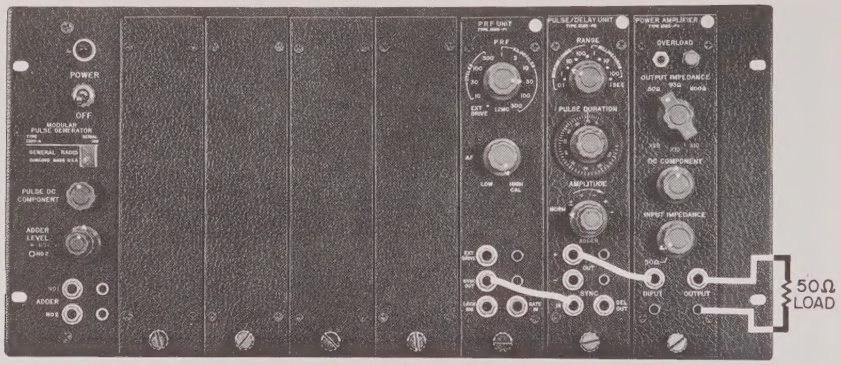

Figure 2-1. The Power Amplifier used to increase the current into a low-impedance load.

The Power Amplifier output voltage will be ten times the input, or between 10 and 20 volts into a 50-ohm load, depending on the setting of the INPUT IMPEDANCE control. In a sense, the INPUT IMPEDANCE control acts as a gain adjustment, although this is not its primary function. Figure 2-1 shows the interconnection for the Power Amplifier used as an impedance-transforming amplifier.

2.2.3 USE AS A VOLTAGE-GAIN AMPLIFIER.

When the Type 1395-P4 is used as a voltage-gain amplifier, it will most likely be connected to the output terminals of an adder in the Type 1395-A main frame. There is a voltage loss in the resistive adder circuits, and the Power Amplifier restores the voltage level. Figure 2-2 shows the interconnection for this application.

2.2.4 INDEPENDENT USE OF THE POWER AMPLIFIER.

The Power Amplifier can be used as an independent amplifier, although even in this case, power should be provided from the Type 1395-A main frame. The signal to be amplified is connected to the INPUT terminals, and the output is taken from the OUTPUT terminals. The maximum input level is hard to define, since some applications can withstand more distortion than others. However, clipping of the output waveform across a 50-ohm load first becomes evident as seen on an oscilloscope with input voltages greater than about 2 volts peak.

2.3 OPERATING TECHNIQUES.

2.3.1 A WARNING.

The output of the Power Amplifier is at a high level. Leads connected to the OUTPUT terminals should be kept physically away from leads to the INPUT terminals, or oscillation may occur. Use shielded leads where practicable to connect to the INPUT and OUTPUT terminals.

2.3.2 SELECTION OF OUTPUT IMPEDANCE.

Three output impedances are provided: 50 ohms, 93 ohms, and 600 ohms. These values permit matching to most of the commonly used cable impedances in video and telephone practice. The OUTPUT IMPEDANCE control should usually be set to the value that most nearly corresponds to the impedance of the load connected to the OUTPUT terminals.

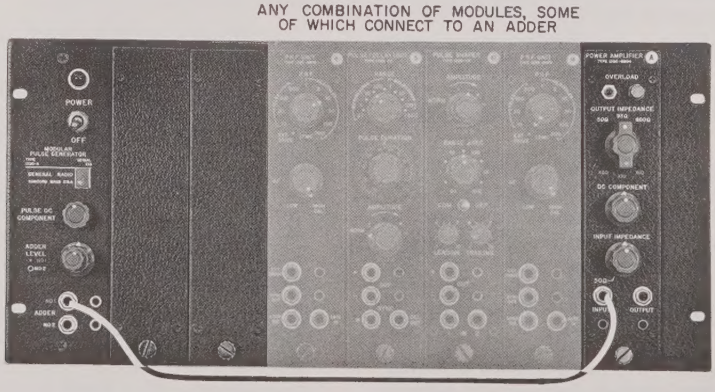

Figure 2-2. Connection of the Power Amplifier to adder to provide voltage gain.

There are a few exceptions. If fast rise time is important, the OUTPUT IMPEDANCE control should be set to 50 ohms and the load impedance made equal to 50 ohms by the use of a dummy load, if necessary. This procedure should also be used for amplification of any waveform with significant high-frequency content. With a 50-ohm OUTPUT IMPEDANCE setting and a 50-ohm load, the Power Amplifier has an upper half-power frequency of 5 Mc/s or higher. With a 600-ohm load and a 600-ohm OUTPUT IMPEDANCE setting, the specified upper half-power frequency drops to 1.5 Mc/s.

2.3.3 SELECTION OF INPUT IMPEDANCE.

2.3.3.1 Choice Based on Terminations. In general, the input impedance should be set equal to the output impedance of the signal source. This is especially important when the INPUT terminals of the Power Amplifier serve as the termination for a transmission line, since an impedance mismatch will cause reflections.

2.3.3.2 Choice Based on Rise Time. The rise time of pulses is 2.2 RC, where R is the resistance into which a pulse of current I flows and C is the capacitance (stray or intentional) shunting the resistance R. The pulse amplitude is IR. A large value of R gives a high amplitude and a poor rise time. Therefore, a choice may be necessary. If the INPUT IMPEDANCE control is set high, the current pulse develops a large input voltage and thereby a large output voltage. If the INPUT IMPEDANCE control is set low, the pulse has a fast rise time but a lower amplitude. The correct decision depends on the circumstances, and these must be evaluated by the user.

2.3.4 THE DC COMPONENT CONTROL.

The DC COMPONENT control permits the selection of the baseline voltage for pulses or the centerline for sinusoidal signals. If this control is centered (arrow pointing straight up), sinusoids and pulses of low duty ratio will be centered about, or originate from, zero volts. Counterclockwise rotation of the control from center shifts the baseline to negative voltages; clockwise rotation makes the baseline positive.

The Power Amplifier is not direct-coupled. There is a capacitor between its INPUT terminals and the first amplifier stage. Therefore, if the duty cycle of pulses varies, the baseline of the pulses will shift. The setting of the DC COMPONENT control must be changed to keep a fixed dc baseline if pulse duty ratio or pulse density changes.

2.3.5 THE POWER AMPLIFIER AND THE WORD GENERATOR.

Use of the DC COMPONENT control discussed in paragraph 2.3.4 is especially important in applications with the Power Amplifier and signals controlled by the Type 1395-P6 Word Generator. A change in the pattern of the Word Generator will often look like a change in pulse density, and therefore, like a change in duty ratio. There are some simple exceptions: change of a binary pattern from 1010... to 0101... will have no effect on pulse density. If a sequence of binary pulses consists of individual pulses having equal positive and negative areas, then no baseline shift will occur for any binary pattern. But as a general rule, when the Word Generator is used with the Power Amplifier, it will be necessary to reset the DC COMPONENT control on the Power Amplifier whenever the binary word is changed, if the baseline voltage is important. There is no inherent objection to using the Word Generator with the Power Amplifier, but the user should be aware of these possibly annoying consequences.

2.3.6 THE OVERLOAD SIGNAL.

If the current drawn from either the +150-volt or the -150-volt dc power supply exceeds 150 mA, the Power Amplifier is turned off and the OVERLOAD light (2 in Figure 1-2) turns on. This light is relatively dim. It will show plainly in ordinary room light, but not if bright sunshine is falling on the front panel.

The overload circuit will sometimes operate on a transient, such as might be created when connections are changed at the INPUT or OUTPUT terminals. Therefore, if the OVERLOAD light comes on, press the OVERLOAD button at once in an attempt to restore power. If there is a true overload, the light will come on again immediately, and it will not be possible to keep the Power Amplifier in operation unless you take one of the following steps:

a. decrease the duty cycle of the input signal,

b. decrease the amplitude of the input signal,

c. increase the load impedance connected to the OUTPUT terminals,

d. change the setting of the DC COMPONENT control so that the average value of the output voltage is closer to zero.

About nine times in ten, the OVERLOAD light will come on as soon as the 30-second time-delay relay in the main frame applies full power to the module after the instrument is first turned on. This falls in the category of operating on a transient, and is nothing to worry about. Simply press the OVERLOAD button to restore power.

2.3.7 A SUGGESTION.

If a Power Amplifier is to be connected to an adder in a semipermanent set-up, it may be convenient to make internal connection between the INPUT terminal of the Power Amplifier and the ADDER bus. ADDER NO. 1 connects to pin 12 on the 14-pin plug on the back of the Power Amplifier; ADDER NO. 2 connects to pin 5 on this plug. Solder a wire from the appropriate pin (12 or 5) to the solder lug behind the INPUT terminal. This makes a permanent, but easily removable, connection between the ADDER and the Power Amplifier input. Place a piece of wooden dowel or similar obstruction in the INPUT terminal so that a second connection will not be made from the front panel while the soldered lead is attached in the rear.

SECTION 3

PRINCIPLES OF OPERATION

3.1 INPUT STAGE.

The input stage, V501, is a conventional pentode amplifier. (Refer to the complete schematic diagram, Figure 4-2.) Feedback from the output is injected at the cathode of V501. The plate load resistance (R513 + R514) is adjustable over a moderate range to allow for tube variations and to permit setting the gain to the value called for in the specifications. A peaking inductor L504 is included to allow adjustment for optimum pulse rise times.

3.2 OUTPUT STAGES.

The output amplifier is a Peterson-Sinclair transformerless push-pull type.[1, 2, 3] A simplified sketch of this amplifier is given in Figure 3-1. The driver stage V502 is a phase inverter. Voltage developed by this tube across resistor R524 is applied between cathode and grid of tubes V505-V506, which are in parallel. Likewise, voltage developed by V502 across R520 is applied between cathode and grid of tubes V503-V504. This results in true push-pull operation. The secret of success is connection of R524 to the high side of the load instead of to ground.

The amplifier is direct-coupled to the right of C509. The dc level on the grid of tube V502 therefore controls the dc voltage at the OUTPUT terminals. The DC COMPONENT control on the panel sets the voltage at the grid of V502, as shown in Figure 3-1.

3.3 OVERLOAD SYSTEM.

The overload circuits are shown in Figure 3-2. Assume that normal currents are being drawn by the power-output stages. Then pilot lights P503 and P502 are dark. No light shines on photo-resistor R503 and the photo-resistor looks like an open circuit. The voltage at the grid of V507 is about -29 volts, and V507 is off. No current flows in the relay or in pilot lamp P501. The relay contacts are both in the up position and power flows to the output stages.

Now assume that excess current is drawn from either the +150-volt or the -150-volt supply. Then either lamp P503 or lamp P502 glows, the photo-resis-

[1] Arnold Peterson and Donald B. Sinclair, "A Single-Ended Push-Pull Audio Amplifier," *Proceedings of the IRE*, Volume 40, Number 1, January, 1952, page 7.

[2] A. P. G. Peterson, "A New Push-Pull Amplifier Circuit," *General Radio Experimenter*, Volume 26, Number 5, October, 1951, page 1.

[3] "A Note on the Single-Ended Push-Pull Amplifier," *General Radio Experimenter*, Volume 26, Number 11, April, 1952, page 11.

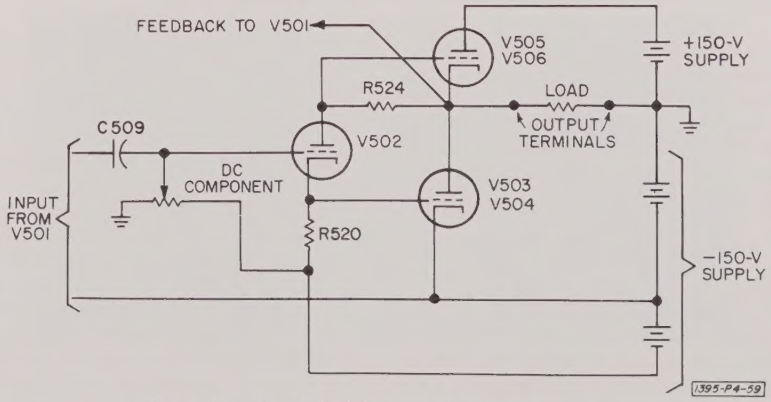

Figure 3-1. Simplified diagram of the output stage.

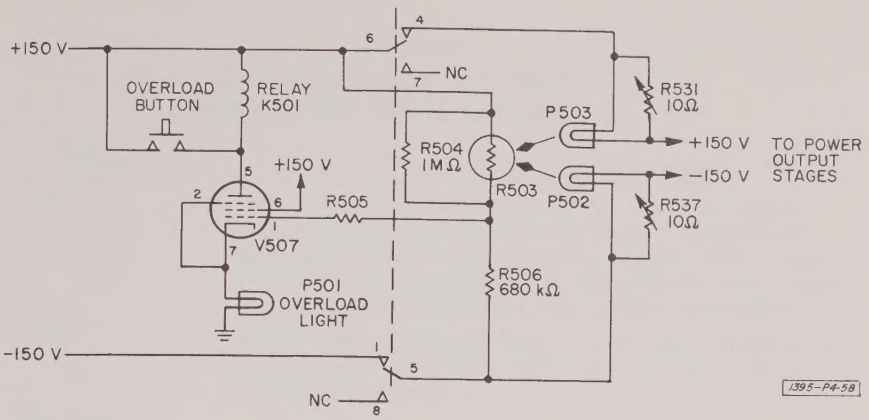

Figure 3-2. Simplified diagram of the overload system.

tor drops to a relatively low value, the voltage on the grid of V507 goes positive, and V507 conducts as hard as possible. The relay turns on, and its contacts move to the down position. This turns off the power to the output stages. Resistor R506 is also left floating. Therefore, the grid of V507 is biased positively even after the relay operates, since it is returned to +150 volts through R505 and R504. R503 again looks like an open circuit. Hence, the relay remains energized and the output stages remain off.

Service is restored when the OVERLOAD button is pressed. This shorts the relay, and allows the relay contacts to return to the up position. If the fault has been removed, or if the overload was caused by a transient, P502 and P503 will remain dark and normal operation resumes.

Resistors R531 and R537 are sensitivity controls for the overload circuit. They shunt most of the current around lamps P502 and P503 so that sufficient light to trip the relay results only from overload conditions.

SECTION 4

SERVICE AND MAINTENANCE

4.1 WARRANTY.

We warrant that each new instrument sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, sales engineering office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

4.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by the use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest sales engineering office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.3 TROUBLE-SHOOTING.

4.3.1 GENERAL.

If a Type 1395-P4 Power Amplifier appears to be inoperative, remember that it will give no output unless it receives an input signal. Check to be sure an input is in fact applied. Also be sure no obvious trouble is overlooked. For example, is the OVERLOAD light calling for attention? Is the Power Amplifier firmly inserted into the Type 1395-A Modular Pulse Generator main frame?

4.3.2 TROUBLE-SHOOTING IN THE TYPE 1395-A MODULAR PULSE GENERATOR.

Make sure that the Type 1395-A Modular Pulse Generator is turned on, and that the power-line voltage and frequency are correct. Be sure that the Type 1395-A is wired for the applied voltage. Check the fuses.

Check the voltages at the connectors on the Type 1395-A, especially at the extreme right-hand connector to which the Power Amplifier is attached. Voltages should be as listed in Table 4-1.

4.3.3 TROUBLE-SHOOTING IN THE POWER AMPLIFIER.

4.3.3.1 General. Remove all the plug-in modules from the Type 1395-A Modular Pulse Generator. Look through the front of the generator toward the fan at the rear. To the right of the fan is an extension cord for connection of a module outside the Type 1395-A Generator. Remove this cord and use it to join the Type

TABLE 4-1

CONNECTOR VOLTAGES THAT AFFECT THE POWER AMPLIFIER

Pin	*Voltage*	*Procedure When Voltage Is Incorrect*
1	+150	The +150-volt level depends on the -150-volt supply. First measure the -150-V level at pin 2 (see below). When the -150-V level is correct and the +150-V level is still wrong, adjust R536. If this does not help, check tubes V501 and V503 in the Type 1395-A main frame.
2	-150	Adjust R525. If this does not correct the -150-V level, check tubes V502, V505, V506, and V507 in the Type 1395-A main frame.
3	Not Applicable	
4	Not Applicable	
5	Not Applicable	
6, 13	6.3 V, 60 c/s, at -75 V dc	Check fuses. If the dc level differs by more than about 10% from -75 volts, suspect a cathode-filament short in V505 or V506 in the Type 1395-A, or one of the plug-ins.
7, 14	6.3 V, 60 c/s, at +50 V dc	Check fuses. If the dc level differs by more than about 10% from +50 volts, suspect a cathode-filament short in one of the plug-ins.
8	Not Applicable	
9	Ground	Check continuity with an ohmmeter. If the resistance between pin 9 and chassis is more than 1 ohm, look for broken wires or cold solder joints.
10	Not Applicable	
11	Not Applicable	
12	Not Applicable	

1395-P4 Power Amplifier to the extreme right-hand connector. Turn on the power. Check visually to be sure that all tube filaments glow.

Table 4-2 lists voltages to be expected on the various tube pins during normal operation.

4.3.3.2 Increasing Input Impedance Trips Overload Circuit. If the OVERLOAD light comes on when the setting of the INPUT IMPEDANCE control is increased, there is not necessarily a fault in the Power Amplifier. Remember that as the INPUT IMPEDANCE control is turned clockwise, more voltage will usually be developed across the INPUT terminals (refer to paragraph 2.3.3). Probably enough additional voltage is developed so the Power Amplifier draws excessive current from the power supplies. The action of the overload circuit is a necessary and proper one under these circumstances.

4.3.3.3 Changing the DC Component Level Trips Overload Circuit. Another symptom that is not a sign of faulty operation is the lighting of the OVERLOAD lamp as the setting of the DC COMPONENT control is changed. When the DC COMPONENT control is turned either side of center, current flows in the load. If the load impedance is small, enough current may flow from just the dc offset to trip the overload circuit. With larger impedance loads, the sum of the signal plus the dc-offset currents can be enough to trip the overload system, whereas the signal current alone would not cause difficulty. To remedy this situation, refer to paragraph 2.3.6.

4.3.3.4 Parasitic Oscillations. The Power Amplifier is almost sure to oscillate if unshielded input and output leads lie close to each other for more than a few inches. Be sure to keep these leads separated. Also, be sure that tubes V501 and V502 are fitted with shields.

4.3.3.5 OVERLOAD Light Remains On All the Time. If the OVERLOAD light remains on at all times, it is probably a genuine sign of trouble. It is possible, however, for the input signal and load to create a set of circumstances that calls for excess current to be drawn from the power supply. Disconnect both the load and the input signal, and see if the fault disappears. Also refer to paragraph 2.3.6.

Another possibility is that resistors R531 and R537 are set to trip the overload relay at abnormally low currents. Try to adjust these resistors according

TABLE 4-2
TABLE OF VOLTAGES

Tube (Type)	Pin	DC Volts to Ground	
V501 (7788)	1	1.7	
	2	0	
	3	1.7	
	4	50	(6.0 V ac)
	5	50	
	6	150	
	7	100	
	8	1.7	
	9	150	
V502 (7788)	1	-131	
	2	-133	
	3	-131	
	4	-75	(6.0 V ac)
	5	-75	
	6	0	
	7	-14	
	8	-131	
	9	0	
V503, V504 (6CW5)	1	-131	
	2	-131	
	3	-118	
	4	-75	(6.0 V ac)
	5	-75	
	6	0	
	7	0	
	8	0	
	9	0	
V505, V506 (6CW5)	1	-15	
	2	-15	
	3	0	
	4	50	(6.0 V ac)
	5	50	
	6	0	
	7	150	
	8	150	
	9	150	
V507 (6AU6)	1	-27	
	2	0	
	3	50	(6.0 V ac)
	4	50	
	5	150	
	6	150	
	7	0	

Switch and Control Settings:

OUTPUT IMPEDANCE: 50 Ω
COMPONENT CONTROL: adjusted for zero dc output
INPUT IMPEDANCE: 50 Ω

to the instructions in paragraph 4.4.1. If this adjustment cannot be made, the Power Amplifier undoubtedly has an internal defect.

The most probable troubles are interelectrode short circuits in tubes V503, V504, V505, and V506. Check all these tubes. A breakdown in CR506, C511, or C514 would also trip the overload circuits.

It is possible for a foreign object to become wedged next to the relay armature so that the relay is held mechanically in a position that causes the OVERLOAD light to be on. Be sure the relay is able to move freely.

4.3.3.6 Severe Distortion in Output Waveform. If there is severe distortion in the output waveform, there is probably major imbalance in the output stage. One of the four output tubes (V503, V504, V505, V506) is likely to be dead.

Another reason for distortion may be that the DC COMPONENT control is set so far to one side or the other that most of the current-carrying capacity of tube pair V503-V504 or tube pair V505-V506 is used to maintain the dc offset and there is no longer adequate reserve current to generate the signal waveform. There is no remedy for this difficulty; the user must decide whether the dc offset or the fidelity of the output waveform is more important in his particular application.

4.3.3.7 Little or No Output, with Extreme DC Offset. If there is little or no output together with extreme and unadjustable dc offset, the trouble is probably in tube V502. Test and replace this tube if necessary.

Other possible, but not likely, causes of this malfunction are: R517, R518, R519, R520, or R524 open or shorted; or leakage through C509.

4.3.3.8 Little or No Output with Satisfactory DC Offset. If there is little or no output but the DC COMPONENT control works properly, tube V501 is probably defective. Test and replace this tube if necessary. Other, but less likely, causes of this malfunction are: C507 or C509 open; or low leakage resistance in C508 or C515.

4.4 NORMAL ADJUSTMENTS AND CALIBRATION.

4.4.1 CURRENT-LIMIT SETTINGS.

Connect the Power Amplifier with the extension cord (mounted in the main frame near the fan) to the extreme right-hand connector in the main frame. Arrange a PRF Unit and a Pulse/Delay Unit to generate 5-μs pulses at a repetition rate of 100 kc/s. Turn the AMPLITUDE control on the Pulse/Delay Unit fully counterclockwise. Connect the + OUT terminal of the Pulse/Delay Unit to the INPUT terminal of the Power

Amplifier. Remove tubes V505 and V506 from the Power Amplifier. Turn R537 fully clockwise. Set the DC COMPONENT control to mid-range. Set the INPUT IMPEDANCE control fully clockwise. Connect a dc milliammeter (0-to-500 mA range) between the OUTPUT terminals, with the + terminal of the meter on ground. Turn on the power.

Now slowly increase the setting of the AMPLITUDE control on the Pulse/Delay Unit (i.e., turn control clockwise). Note the indication on the milliammeter at which the OVERLOAD light comes on. This should be less than 150 mA. (If the OVERLOAD light does not come on before the meter reads 150 mA, lamp P502 is defective. This lamp is inside the black cylinder mounted on the printed board.) Now rotate R537 a few degrees counterclockwise, push the OVERLOAD button, and continue to increase the setting of the AMPLITUDE control on the Pulse/Delay Unit until the OVERLOAD light comes on again. The current on the milliammeter at this moment will be larger than before, but probably still less than 150 mA. Continue to turn R537 counterclockwise gradually and to raise the amplitude of the input signal until the meter reads 150 mA at the time the relay cuts off the current. Turn off the instrument and replace tubes V505 and V506.

Now remove tubes V503 and V504. Set R531 fully clockwise. Reverse the milliammeter connections so that the − terminal of the meter is grounded. Turn on the power.

Slowly increase the setting of the AMPLITUDE control on the Pulse/Delay Unit. Note the indication on the milliammeter when the OVERLOAD light comes on. This reading should be less than 150 mA; if it is not, lamp P503 in the black cylinder is defective. Now rotate R531 a few degrees counterclockwise, push the OVERLOAD button, and continue to increase the AMPLITUDE of the Pulse/Delay Unit until the OVERLOAD light comes on again. The current on the milliammeter will be a little larger than before. Continue to turn R531 counterclockwise gradually and raise the amplitude of the input signal until the meter reads 150 mA at the time the relay cuts off the current. Turn off the power and replace tubes V503 and V504.

4.4.2 GAIN ADJUSTMENT.

Connect the Power Amplifier with an extension cable to the extreme right-hand socket in the main frame. Apply a sinusoidal signal of 1 volt rms, 10 kc/s in frequency, to the INPUT terminals. Set the OUTPUT IMPEDANCE control to 50 ohms. Connect an accurate 50-ohm resistive load to the OUTPUT terminals. Turn on the power. Measure the voltage across the load resistor. Adjust R514 (on the back panel near the top) until the load voltage is exactly 10 volts rms.

4.4.3 ADJUSTMENT OF RISE AND FALL TIME.

Connect the Power Amplifier with an extension cable to the right-hand socket in the main frame. Set the INPUT IMPEDANCE control to 50 ohms. Connect an accurate 50-ohm load to the OUTPUT terminals, and set the OUTPUT IMPEDANCE control to 50 ohms.

Apply a fast-rise-time pulse, such as that supplied by the General Radio Type 1394-A High-Rate Pulse Generator or a mercury pulser, to the INPUT terminals. This should be a positive pulse with an amplitude not over 1 volt. Turn on the power. Examine the OUTPUT terminal waveform with a cathode-ray oscilloscope. The rise time of the oscilloscope (including plug-in, if any) should be 15 nanoseconds or faster. Now adjust L504 for optimum performance, which is most easily seen on the trailing edge of the output pulse. Factory adjustment calls for the trailing edge to fall as fast as possible without overshoot. However, for particular applications, it may be preferable to put up with some overshoot to obtain faster transition times.

4.5 MINIMUM PERFORMANCE STANDARD.

TABLE 4-3
TEST EQUIPMENT REQUIRED

Equipment	*Necessary Specifications*	*Recommended Equipment**
Volt-ohmmeter	20,000 Ω/V	Simpson 270
Resistor	50-Ω ±1%, 8-W	Use 3 150-Ω, 3-W resistors in parallel
Resistor	93 Ω ±1%, 5-W	Use 2 270-Ω and 1 300-Ω, 2-W resistors in parallel
Resistor	600-Ω ±1%, 1-W	GR Type 500-G Resistor
Distortion meter	Must have calibrated 10-dB/step attenuator	GR Type 1932 Distortion and Noise Meter
Audio signal generator	20 Hz to 20 kHz, with 5-V, 500-mW adjustable calibrated output level, less than 0.5% distortion	GR Type 1304 Beat-Frequency Oscillator
Radio-frequency signal generator	Capable of producing a 2-V, 5-MHz signal across 50 Ω	GR Type 1330 Bridge Oscillator
AC impedance bridge	1% accuracy	GR Type 1650 Impedance Bridge
Vacuum-tube voltmeter		GR Type 1806 Electronic Voltmeter
Oscilloscope	20-MHz bandwidth, dual-trace	Tektronix Type 543 with Type 1A2 or Type CA Plug-In Unit
Pulse generator	Capable of producing positive or negative 2-V, 100-kHz pulses with variable duration to less than 0.4 μs and less than 15-ns rise time across 50 Ω	GR Type 1217 Unit Pulse Generator or Type 1398 Pulse Generator
Modular Pulse Generator (main frame)	(no substitution)	Type 1395-A
Coaxial patch cords (2)	Double plug to GR874	GR Type 874-R34
Coaxial patch cord (1)	GR874 to GR874	GR Type 874-R20A
Coaxial tee connector (1)	GR874 connectors	GR Type 874-Tee Connector
Resistance pad	50-Ω, 20-dB attenuation	GR Type 874-G20 Attenuator
Clip leads (2)		

*Suitable equivalent may be substituted, except where noted.

NOTE

This procedure assumes that the Type 1395-A (main frame) is functioning properly in accordance with its own minimum performance standard.

4.5.1 INPUT IMPEDANCE.

Connect the VOM across the INPUT terminals of the Type 1395-P4. Vary the INPUT IMPEDANCE control. The dc resistance measured by the VOM must be 50 Ω ±2% with the control fully ccw and between 950 Ω and 1150 Ω in the cw position.

4.5.2 GAIN.

Use the following procedure to measure the gain of the power amplifier.

a. Plug the Type 1395-P4 into the far right-hand slot in the Type 1395-A.

b. Set the INPUT IMPEDANCE and OUTPUT IMPEDANCE controls to 50 Ω.

c. Terminate the OUTPUT terminals in 50 Ω.

d. Set the range of the VOM to read between +10 and +15 Vdc and connect it to the OUTPUT terminals of the Type 1395-P4.

e. Adjust the DC COMPONENT control for 0-Vdc output as measured on the VOM, then disconnect the VOM.

Adjust the controls of the distortion meter as follows:

METER READS . . . . . NOISE - CAL
INPUT . . . . . 100 kΩ
NOISE LEVEL . . . . . -20 dB
CAL control . . . . . Adjust for a 2-dB meter reading.

f. Apply a sinewave of about 2.0 V, rms, at 1 kHz from audio signal generator to the input terminals of the distortion meter.

NOTE

The control settings listed above apply to the Type 1932 Distortion and Noise Meter. If another type of instrument is used, adjustments will have to be made accordingly.

g. Apply the output of the Type 1395-P4 to the input of the distortion meter (the 50-Ω termination should be left in place). The distortion meter should read -2 dB (when the 0 dB button of the Type 1932 is pressed). If necessary, adjust R514 at the rear of the Type 1395-P4 to obtain this reading.

(In order to make this adjustment it will be necessary to: (1) Turn the main frame POWER off. (2) Remove the Type 1395-P4 from the main frame. (3) Connect the Type 1395-P4 to the main frame far right-hand socket via the extension cord provided. (4) Turn the POWER back on.)

h. Replace the 50-Ω load with a 93-Ω load. Set the OUTPUT IMPEDANCE switch of Type 1395-P4 to 93 Ω. The distortion meter should indicate between 0 and -4 dB.

i. Replace the 93-Ω load with 600 Ω. Connect the distortion meter to the Type 1395-P4 INPUT. Set the distortion meter range to -20 dB and adjust the CAL control of the distortion meter for a reading of -8 dB.

j. Transfer the input of the distortion meter to the Type 1395-P4 OUTPUT. Set the meter range to 0 dB. The meter should indicate between 0 and -4 dB.

4.5.3 OUTPUT IMPEDANCE.

The following procedure checks the output impedance of the Type 1395-P4 to be within specified limits.

a. Disconnect the audio signal generator and the 600-Ω load from the Type 1395-P4, and reset the DC COMPONENT control to 0 Vdc as in steps d and e of paragraph 2.0.

b. Connect the UNKNOWN terminals of the impedance bridge to the OUTPUT terminals of the Type 1395-P4. If the Type 1650 is used, set the mode switch to INT 1 kc.

c. Set the INPUT IMPEDANCE and OUTPUT IMPEDANCE of the Type 1395-P4 to 50 Ω.

d. Measure "R" with the impedance bridge according to the directions in its instruction manual. Should be between 46 and 54 Ω with the Type 1395-P4 on, that is, plugged into a main frame with the POWER on.

e. Set the OUTPUT IMPEDANCE switch to 93 Ω. R should be between 85 and 101 Ω with the Type 1395-P4 on.

f. Set the OUTPUT IMPEDANCE switch to 600 Ω. R should be between 550 and 650 Ω with the Type 1395-P4 on.

4.5.4 OPEN-CIRCUIT VOLTAGE.

Measure the output voltage of the power amplifier to be as specified accordingly:

a. Connect the audio generator to the INPUT of the Type 1395-P4.

b. Connect the vertical input of the oscilloscope and the VTVM to the OUTPUT of the Type 1395-P4.

c. Set the various controls as follows:

Type 1395-P4	OUTPUT IMPEDANCE	50 Ω
	INPUT IMPEDANCE	50 Ω
Signal generator	Frequency	10 kHz
Voltmeter	Range	150 Vac

d. Adjust the oscilloscope controls to obtain a trace of the Type 1395-P4 output signal.

e. Adjust the output level of the signal generator to a level just below visible distortion of the waveform on the oscilloscope. The voltmeter must indicate an output level of between 40 and 55 V, rms.

f. Set the OUTPUT IMPEDANCE to 93 Ω and repeat step e.

g. Set the OUTPUT IMPEDANCE to 600 Ω and repeat step e.

4.5.5 FREQUENCY RESPONSE.

The following procedure verifies that the Type 1395-P4 frequency response is as specified.

a. Connect the radio frequency generator, the audio signal generator, the Type 1395-P4, and the oscilloscope as shown in Figure 4-1.

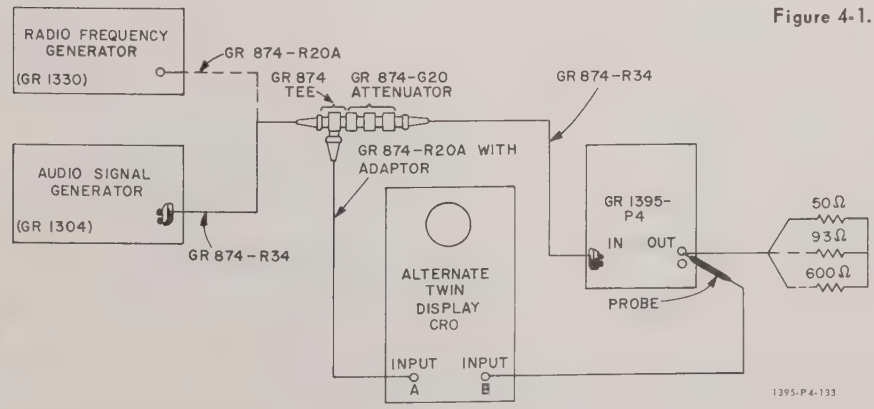

Figure 4-1. Test set-up for frequency-response check.

b. Set the following controls:

Type 1395-P4	INPUT IMPEDANCE	50 Ω
	OUTPUT IMPEDANCE	50 Ω
Oscilloscope	Mode	Alternate (dual trace)
	Channel "A" Sensitivity	0.5 V/division
	Channel "B" Sensitivity	0.05 V/division
Audio signal generator Frequency		20 Hz

c. Check the oscilloscope probe compensation. The gain of the two channels must be equal.

d. Adjust the audio signal generator output level to produce an amplitude of four divisions on channel A of the oscilloscope. The amplitude of channel B must be between three and four divisions.

e. Repeat step d using the radio frequency generator at a frequency of 5 MHz in place of the audio signal generator. The results should be the same.

f. Set the OUTPUT IMPEDANCE of the Type 1395-P4 to 93 Ω and terminate the OUTPUT with a 93-Ω load resistor.

g. Repeat steps d and e with the new output impedance.

h. Set the OUTPUT IMPEDANCE of the Type 1395-P4 to 600 Ω and terminate the OUTPUT with a 600-Ω load resistor.

i. Connect the audio signal generator as in Figure 1 and adjust its output level at 20 Hz to produce an amplitude of 2 divisions on channel A of the oscilloscope. The amplitude of channel B must be between three and four divisions.

j. Repeat step i using the radio-frequency generator at a frequency of 1.5 MHz in place of the audio-signal generator.

4.5.6 SINEWAVE POWER OUTPUT.

Check the Type 1395-A sinewave output power as follows:

a. Set the INPUT IMPEDANCE and OUTPUT IMPEDANCE controls of the Type 1395-P4 to 50 Ω and terminate its OUTPUT terminals in 50 Ω.

b. Set the frequency of the audio signal generator to 1 kHz and connect it to the INPUT terminals of the Type 1395-P4.

c. Connect the distortion meter and the voltmeter across the OUTPUT of the Type 1395-P4. If the Type 1932 is used, set its INPUT control to 100 kΩ, METER READS to DIST, and DISTORTION - NOISE LEVEL to 10%. Set the voltmeter range to 15 Vac.

d. Adjust the signal generator level to produce a reading of 11.5 V on the voltmeter. Distortion should be less than 5%.

e. Repeat step d with an OUTPUT termination and OUTPUT IMPEDANCE setting 93 Ω. Distortion should again be less than 5% with an output level of 11.5 Vac.

f. Set the voltmeter range to 150 Vac. Terminate the Type 1395-P4 in 600 Ω and set the OUTPUT IMPEDANCE to this value. Adjust the input signal level to obtain a reading of 30.0 Vac on the voltmeter. Distortion must be less than 3%.

4.5.7 DC LEVEL CHECKS.

Check the DC levels of the Type 1395-P4 to be as specified accordingly:

a. Terminate the Type 1395-P4 in 50 Ω and set its OUTPUT IMPEDANCE to 50 Ω.

b. Connect the vertical input of the oscilloscope across the OUTPUT of the Type 1395-P4.

c. Turn the DC COMPONENT control of the Type 1395-P4 fully cw. The positive dc shift even on the oscilloscope must be at least 2.0 V.

d. Turn the DC COMPONENT control fully ccw. The negative dc shift must be at least 2.0 V.

4.5.8 PULSE OUTPUT POWER.

The following procedure verifies the specified output power level.

a. Set the INPUT and OUTPUT IMPEDANCE controls to 50 Ω and terminate the OUTPUT of the Type 1395-P4 in 50 Ω.

b. Adjust the DC COMPONENT control as in steps 2.0 d and e to produce a 0-V dc output.

c. Connect the + output pulse terminals of the pulse generator to the INPUT of the Type 1395-P4. Set the PRF of the pulse generator to 100 kilocycles and the pulse duration to 1 microsecond.

d. Connect the vertical input of the oscilloscope to the OUTPUT of the Type 1395-P4.

e. Adjust the output level of the pulse generator for maximum possible amplitude before the relay in the Type 1395-P4 trips. The measured peak voltage shown on the oscilloscope must be at least 20 V.

f. Change the connection of the Type 1395-P4 from the + to the - pulse output terminals of the pulse generator and repeat step e.

4.5.9 RISE TIME.

The following procedure verifies the specified output-pulse transition times:

a. Set up the Type 1395-P4 as in a and b of section 4.5.8.

b. Set the PRF of the pulse generator to 100 kilocycles, the pulse duration to 0.4 microseconds, and the amplitude to 20 V, p-p. Connect the + output pulse terminals to the input of the Type 1395-P4.

c. Connect the vertical input of the oscilloscope to the OUTPUT terminals of the Type 1395-P4. Use external sweep triggering and a sweep rate of 50 ns/division.

d. Measure the rise and fall times of the positive and negative transitions to be less than 60 ns.

NOTE

The unit of frequency is the hertz, which is equivalent to one cycle per second. The abbreviation of hertz is Hz, which is used in more recently included sections of this book, replacing the older c/s.

PARTS LIST

REF NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
CAPACITORS					
C501	Electrolytic, 16 µF +100 -10% 150 V	4450-0200	37942	D33104	5910-931-7064
C502	Ceramic, 0.001 µF +80 -20% 500 V	4404-2109	72982	831, 0.001 µF +80-20%	5910-983-9994
C503	Electrolytic, 16 µF +100 -10% 150 V	4450-0200	37942	D33104	5910-931-7064
C504	Electrolytic, 16 µF +100 -10% 150 V	4450-0200	37942	D33104	5910-931-7064
C505	Ceramic, 0.001 µF +80 -20% 500 V	4404-2109	72982	831, 0.001 µF +80-20%	5910-983-9994
C506	Electrolytic, 16 µF +100 -10% 150 V	4450-0200	37942	D33104	5910-931-7064
C507	Plastic, 0.47 µF ±10% 200 V	4860-8247	84411	663UW, 0.47 µF ±10% 200 V	
C508	Ceramic, 0.047 µF +80 -20% 500 V	4409-3479	72982	3851, 0.047 µF +80-20%	
C509	Plastic, 0.47 µF ±10% 400 V	4860-9725	84411	663F, 0.47 µF ±10% 400 V	
C510	Electrolytic, 600 µF +100 -10% 3 V	4450-5589	37942	TCM, 600 µF +100-10%	
C511	Electrolytic, 16 µF +100 -10% 150 V	4450-0200	37942	D33104	5910-931-7064
C512	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229	72982	CC63, 0.022 µF +80-20%	5910-842-2961
C513	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229	72982	CC63, 0.022 µF +80-20%	5910-842-2961
C514	Ceramic, 0.022 µF +80 -20% 500 V	4407-3229	72982	CC63, 0.022 µF +80-20%	5910-842-2961
C515	Ceramic, 8.2 pF ±10% 500 V	4400-0951	78488	GA, 8.2 pF ±10%	
C516	Ceramic, 15 pF ±5% NPO	4410-0155	56289	40C507, 15 pF ±5%	
DIODES					
CR501	Type 1N645	6082-1016	24446	1N645	5961-944-8222
CR502 through CR505	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR506	Type 1N2989B	6083-1041	28959	1N2989B	
JACKS					
J501	INPUT, Metal Bushing	4150-3200	24655	4150-3200	
J502	OUTPUT, Metal Bushing	4150-3200	24655	4150-3200	
J503	INPUT, Ground, Forced Insert	5440-2727	24655	5440-2727	
J504	OUTPUT, Ground, Forced Insert	5440-2727	24655	5440-2727	
RELAYS					
K501	2500 Ω ±10%, Sigma Instrument, Type 42 F (DPDT)	6090-1000	78277	42F (DPDT) 2500 Ω ±10%	
INDUCTORS					
L501	Choke, 68 µH ±10%	4300-3300	99800	2890, 68 µH ±10%	
L502	Choke, 68 µH ±10%	4300-3300	99800	2890, 68 µH ±10%	
L504	Air Choke, 8.5 - 14.6 µH	4290-4000	98821	1000-E, 8.5-14.6 µH	
PILOT LIGHTS					
P501	10 V, #344, OVERLOAD	5600-0314	71744	#344	
P502	1.3 V, #331	5600-0308	71744	#331	
P503	1.3 V, #331	5600-0308	71744	#331	
PLUG					
PL501	14 Connector, Female, Amphenol No. 57-10140	4220-5307	02660	57-10140	
RESISTORS					
R501	Composition, 160 kΩ ±5% 1/2 W	6100-4165	01121	RC20GF164J	5905-279-1871
R502	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R503	Photoresistor, 7.2 kΩ in light	6740-2000	03911	CL503, 7.2 kΩ	
R504	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R505	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R506	Composition, 680 kΩ ±5% 1/2 W	6100-4685	01121	RC20GF684J	5905-171-2000
R507	Film, 49.9 Ω ±1% 1/2 W	6450-9499	75042	CEC-TO, 49.9 Ω ±1%	
R508	POTENTIOMETER, Composition 1 kΩ ±10%	6000-0300	01121	JU, 1 kΩ ±10%	5905-644-6789
R509	Composition, 270 kΩ ±5% 1/2 W	6100-4275	01121	RC20GF274J	5905-190-8865
R510	Composition, 27 Ω ±5% 1/2 W	6100-0275	01121	RC20GF270J	5905-279-1879

REF NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
RESISTORS (Cont)					
R511	Composition, 27 Ω ±5% 1/2 W	6100-0275	01121	RC20GF270J	5905-279-1879
R512	Composition, 27 Ω ±5% 1/2 W	6100-0275	01121	RC20GF270J	5905-279-1879
R513	Composition, 1.0 kΩ ±5% 2 W	6120-2105	01121	RC42GF102J	5905-256-3361
R514	POTENTIOMETER, Composition 500 Ω ±10%	6010-0300	01121	JU, 500 Ω ±10%	5905-448-5741
R515	Composition, 27 Ω ±5% 1/2 W	6100-0275	01121	RC20GF270J	5905-279-1879
R516	Composition, 33 kΩ ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R517	Film, 33 kΩ ±1% 1 W	6550-2330	75042	MEF, 33 kΩ ±1%	
R518	POTENTIOMETER, Composition 2.5 kΩ ±10%	6000-0400	12697	53MS, 2.5 kΩ ±10%	5905-034-5378
R519	Film, 3.01 kΩ ±1% 1/2 W	6450-1301	75042	CEC, 3.01 kΩ ±1%	5905-518-5924
R520	Composition, 620 Ω ±5% 1/2 W	6100-1625	01121	RC20GF621J	5905-279-1761
R521	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R522	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R524	Composition, 560 Ω ±5% 1/2 W	6100-1565	01121	RC20GF561J	5905-195-6800
R525	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R526	Composition, 4.7 Ω ±5% 1/4 W	6099-9475	75042	BTS, 4.7 Ω ±5%	
R527	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R528	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R529	Composition, 4.7 Ω ±5% 1/4 W	6099-9475	75042	BTS, 4.7 Ω ±5%	
R530	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R531	POTENTIOMETER, Composition 10 Ω ±10%	6058-0105	75042	CT-100, 10 Ω ±10%	
R532	Composition, 4.7 Ω ±5% 1/4 W	6099-9475	75042	BTS, 4.7 Ω ±5%	
R533	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R534	Composition, 4.7 Ω ±5% 1/4 W	6099-9475	75042	BTS, 4.7 Ω ±5%	
R535	Composition, 27 Ω ±5% 1/4 W	6099-0275	75042	BTS, 27 Ω ±5%	
R536	Composition, 300 ± ±5% 2 W	6120-1305	01121	RC42GF301J	5905-279-2024
R537	POTENTIOMETER, Composition 10 Ω ±10%	6058-0105	75042	CT-100, 10 Ω ±10%	
R538	Wire-wound, 2.5 kΩ ±1% 3 W	6680-2251	80183	242E, 2.5 kΩ ±1%	
R539	Wire-wound, 1.0 kΩ ±1% 3 W	6680-2101	80183	242E, 1.0 kΩ ±1%	
R540	Film, 422 Ω ±1% 1/2 W	6450-9422	75042	CEC-TO, 422 Ω ±1%	
R541	Film, 82.5 Ω ±1% 1/2 W	6450-9825	75042	CEC-TO, 82.5 Ω ±1%	
R542	Composition, 130 Ω ±5% 1/2 W	6100-1135	01121	RC20GF131J	5905-252-5436
SWITCHES					
S501	Rotary Wafer, OUTPUT IMPEDANCE	7890-3890	76854	Type F	
S502	Pushbutton, OVERLOAD	7870-1120	81073	30-1 N. O.	
TUBES					
V501	Type 7788	8380-7788	73445	7788	5960-088-6529
V502	Type 7788	8380-7788	73445	7788	5960-088-6529
V503 through V506	Type 6CW5	8360-4423	73445	6CW5	5960-087-3086
V507	Type 6AU6	8360-2100	49956	CAU6	5960-617-9920
KNOBS					
——	OUTPUT IMPEDANCE Knob	5500-1825	24655	5500-1825	
——	OUTPUT-IMPEDANCE-Knob Bushing (7/16-in)	4140-0300	24655	4140-0300	
——	DC COMPONENT Knob	5530-0300	24655	5530-0300	
——	INPUT IMPEDANCE Knob	5530-0300	24655	5530-0300	

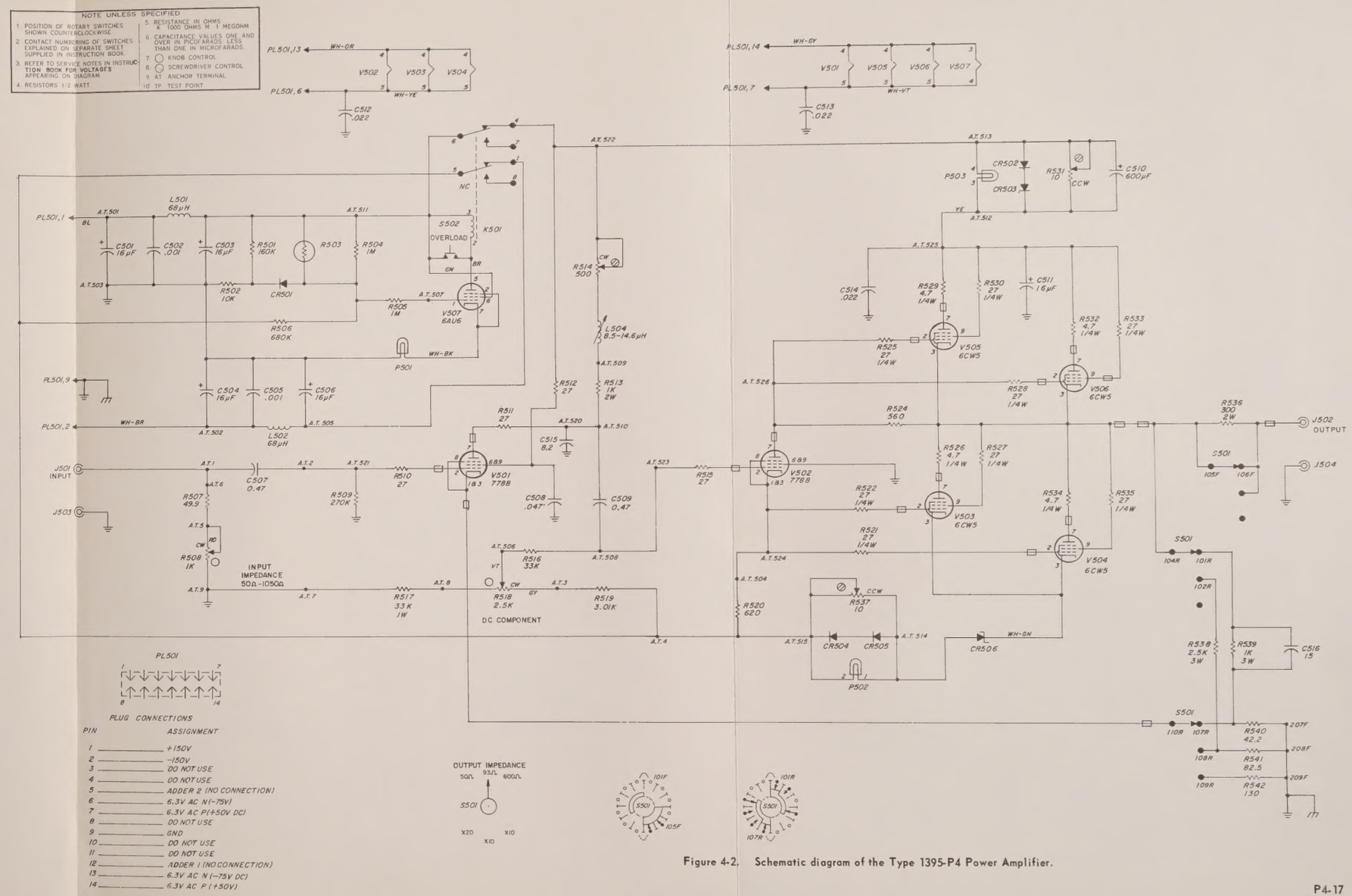

Figure 4-2. Schematic diagram of the Type 1395-P4 Power Amplifier.

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FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Clairex Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004
07828	Bodine Corp., Bridgeport, Conn. 06605
07829	Bodine Electric Co., Chicago, Ill. 60618
07910	Continental Device Corp., Hawthorne, Calif.
07983	State Labs Inc., N. Y., N. Y. 10003
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
08730	Vemaline Prod. Co., Franklin Lakes, N. J.
09213	General Electric Semiconductor, Buffalo, N. Y.
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11599	Chandler Evans Corp., W. Hartford, Conn.
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140
12672	RCA Commercial Receiving Tube and Semi-conductor Div., Woodridge, N.J.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820
12954	Dickson Electronics Corp., Scottsdale, Ariz.
13327	Solitrone Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T, Lawrence, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
24446	G. E. Schenectady, N. Y. 12305
24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co., W. Concord, Mass 01781
26806	American Zettler Inc., Costa Mesa, Calif.
28520	Hayman Mfg. Co., Kenilworth, N. J.
28959	Hoffman Electronics Corp., El Monte, Calif.
30874	International Business Machines, Armonk, N.Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638
35929	Constapta Co. of Canada Limited, Montreal 19, Quebec
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.
40931	Honeywell Inc., Minneapolis, Minn. 55408
42190	Muter Co., Chicago, Ill. 60638
42498	National Co. Inc., Melrose, Mass. 02176
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904
49671	RCA, New York, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154
53021	Sangamo Electric Co., Springfield, Ill. 62705
54294	Shallcross Mfg. Co., Selma, N. C.
54715	Shure Brothers, Inc., Evanston, Ill.
56289	Sprague Electric Co., N. Adams, Mass.
59730	Thomas and Betts Co., Elizabeth, N. J. 07207
59875	TRW Inc. (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg. Co., Torrington, Conn.
61637	Union Carbide Corp., New York, N. Y. 10017
61864	United-Carr Fastener Corp., Boston, Mass.
63060	Victoreen Instrument Co., Inc., Cleveland, Ohio
63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.
65083	Westinghouse (Lamp Div), Bloomfield, N. J.
65092	Weston Instruments, Weston-Newark, Newark, N. J.
70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607
70563	Amperite Co., Union City, N. J. 07087
70903	Belden Mfg. Co., Chicago, Ill. 60644
71126	Bronson, Homer D., Co., Beacon Falls, Conn.
71294	Canfield, H. O. Co., Clifton Forge, Va. 24422
71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.
71590	Centralab, Inc., Milwaukee, Wisc. 53212
71666	Continental Carbon Co., Inc., New York, N. Y.
71707	Coto Coil Co. Inc., Providence, R. I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624
71823	Darnell Corp., Ltd., Downey, Calif. 90241
72136	Electro Motive Mfg. Co., Willmington, Conn.
72259	Nytronics Inc., Berkeley Heights, N. J. 07922
72619	Dialight Co., Brooklyn, N. Y. 11237
72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104
72765	Drake Mfg. Co., Chicago, Ill. 60656
72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp., Union, N. J. 07083
72982	Erie Technological Products Inc., Erie, Penn.
73445	Amperex Electronics Co., Hicksville, N. Y.
73559	Carling Electric Co., W. Hartford, Conn.
73690	Elco Resistor Co., New York, N. Y.
73899	J. F. D. Electronics Corp., Brooklyn, N. Y.
74193	Heinemann Electric Co., Trenton, N. J.
74861	Industrial Condenser Corp., Chicago, Ill.
74970	E. F. Johnson Co., Waseca, Minn. 56093
75042	IRC Inc., Philadelphia, Penn. 19108
75382	Kulka Electric Corp., Mt. Vernon, N. Y.
75608	Linden and Co., Providence, R. I.
75915	Littelfuse, Inc., Des Plaines, Ill. 60016
76005	Lord Mfg. Co., Erie, Penn. 16512
76487	James Millen Mfg. Co., Malden, Mass. 02148
76545	Mueller Electric Co., Cleveland, Ohio 44114
76684	National Tube Co., Pittsburg, Penn.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77147	Patton MacGuyer Co., Providence, R. I.
77166	Pass-Seymour, Syracuse, N. Y.
77263	Pierce Roberts Rubber Co., Trenton, N. J.
77339	Positive Lockwasher Co., Newark , N. J.
77542	Ray-O-Vac Co., Madison, Wisc.
77630	TRW, Electronic Component Div., Camden, N. J. 08103
77638	General Instruments Corp., Brooklyn, N. Y.
78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120
78277	Sigma Instruments Inc., S. Braintree, Mass.
78488	Stackpole Carbon Co., St. Marys, Penn.
78553	Tinnerman Products, Inc., Cleveland, Ohio
79089	RCA, Commercial Receiving Tube and Semi-conductor Div., Harrison, N. J.
79725	Wiremold Co., Hartford, Conn. 06110
79963	Zierick Mfg. Co., New Rochelle, N. Y.
80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio
80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.
80131	Electronic Industries Assoc., Washington, D.C.
80211	Motorola Inc., Franklin Park, Ill. 60131
80258	Standard Oil Co., Lafeyette, Ind.
80294	Bourns Inc., Riverside, Calif. 92506
80431	Air Filter Corp., Milwaukee, Wisc. 53218
80583	Hammarlund Co. Inc., New York, N. Y.
80740	Beckman Instruments, Inc., Fullerton, Calif.
81073	Grayhill Inc., LaGrange, Ill. 60525
81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp., Yonkers, N. Y.
81831	Filton Co., Flushing, L. I., N. Y
81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
82273	Indiana Pattern and Model Works, LaPort, Ind.
82389	Switchcraft Inc., Chicago, Ill. 60630
82647	Metals and Controls Inc., Attleboro, Mass.
82807	Milwaukee Resistor Co., Milwaukee, Wisc.
83058	Carr Fastener Co., Cambridge, Mass.
83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
83361	Bearing Specialty Co., San Francisco, Calif.
83587	Solar Electric Corp., Warren, Penn.
83740	Union Carbide Corp., New York, N. Y. 10017
84411	TRW Capacitor Div., Ogallala, Nebr.
84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
84971	TA Mfg. Corp., Los Angeles, Calif.
86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
86684	RCA (Electrical Component and Devices) Harrison, N. J.
88140	Cutler-Hammer Inc., Lincoln, Ill.
88219	Gould Nat. Batteries Inc., Trenton, N. J.
88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
88627	K and G Mfg. Co., New York, N. Y.
89482	Holtzer Cabot Corp., Boston, Mass.
89665	United Transformer Co., Chicago, Ill.
90201	Mallory Capacitor Co., Indianapolis, Ind.
90750	Westinghouse Electric Corp., Boston, Mass.
90952	Hardware Products Co., Reading, Penn. 19602
91032	Continental Wire Corp., York, Penn. 17405
91146	ITT Cannon Electric Inc., Salem, Mass.
91293	Johanson Mfg. Co., Boonton, N. J. 07005
91598	Chandler Co., Wethersfield, Conn. 06109
91637	Dale Electronics Inc., Columbus, Nebr.
91662	Elco Corp., Willow Grove, Penn.
91719	General Instruments, Inc., Dallas, Texas
91929	Honeywell Inc., Freeport, Ill.
92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
92678	Edgerton, Germeshausen and Grier, Boston, Mass.
93332	Sylvania Electric Products, Inc., Woburn, Mass.
93916	Cramer Products Co., New York, N. Y. 10013
94144	Raytheon Co. Components Div., Quincy, Mass.
94154	Tung Sol Electric Inc., Newark, N. J.
95076	Garde Mfg. Co., Cumberland, R. I.
95146	Alco Electronics Mfg. Co., Lawrence, Mass.
95238	Continental Connector Corp., Woodside, N. Y.
95275	Vitramon, Inc., Bridgeport, Conn.
95354	Methode Mfg. Co., Chicago, Ill.
95412	General Electric Co., Schenectady, N. Y.
95794	Ansconda American Brass Co., Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
96214	Texas Instruments Inc., Dallas, Texas 75209
96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
96341	Microwave Associates Inc., Burlington, Mass.
96906	Military Standards
97966	CBS Electronics Div. of Columbia Broadcasting Systems, Danvers, Mass.
98291	Sealectro Corp., Mamaroneck, N. Y. 10544
98821	North Hills Electronics Inc., Glen Cove, N. Y.
99180	Transitron Electronics Corp., Melrose, Mass.
99378	Atlee Corp., Winchester, Mass. 01890
99800	Delevan Electronics Corp., E. Aurora, N. Y.